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RADC-TR-74-191
Final Report
January 1975

EXPERIMENTAL IMAGE COMPRESSION SUBSYSTEM (EICS)

Radiation, Inc

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Rome Air Development Center
Air Force Systems Command
Griffiss Air Force Base, New York 13441

This report summarizes the system design, and the in-plant tests of the Experimental Image Compression Subsystem (EICS), which was designed jointly by IRDE personnel and Radiation, Inc. The RADC Project Engineer was Mr. James J. Maier (IRDE); the Job Order No. 27160501.

Individuals who contributed to the design and planning were Messrs George Hughes/Supervisory Engineer; Lawrence Odell/2716 Program Manager; Arnold Lanckton/Consultant; Robert Smeland/ Testing; and John Yust/Radiation Designer.

Appreciation is extended to Colonel Lorenzo Burroughs and Major Thomas McGraw, USAF, for contributing to the development of requirements and to Mr. Robert Smeland and Lt David Boyle for demonstrating and testing the EICS in the field. These results will follow at a later date.

This report has been reviewed and is approved for publication.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Experimental Imagery Compression Subsystem (EICS) is a hardware system which evolved from a U. S. Air Force Suggestion idea, further expanded under study to Radiation, Inc., simulated by using the RADC computer facilities, and designed under contract to Radiation, Inc.

The system is mainly designed to reduce the great bulk of data in intelligence imagery by dividing the photo into target and non-target areas for compression

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by the joint use of three compression algorithms.

The system is designed to perform at a 9.6 KB/S output rate due to inherent narrow bandwidths of existing communication channels. If wider bandwidths are available, it can be easily changed to operate at a faster pace.

EVALUATION

The Experimental Image Compression Subsystem is an outgrowth of RADC's developmental responsibilities in the area of preprocessing of imagery data for compression and transmission via narrow band circuits. The original study began under Advanced Development 698DB and 1181, and evolved from a study to a software simulation, to the present system.

The system is to be demonstrated and tested by transmitting between Melbourne, Flordia and Griffiss AFB. After the initial demonstrations between these two sites, the system will be evaluated further by several DOD agencies.

The photos shown in this report have been transmitted from one terminal to the receiving terminal in the laboratory, by hardwiring the system without a modem. For the field demonstrations, a Codex 9.6 KB/S modem will be interfaced for transmission over leased C-2 lines.

The EICS is a unique system which combines the joint use of the three algorithms such that a net data compression is obtained throughout one frame of the imagery. The EICS functions by handshaking between the laser image terminal, and the Datacraft machine. When the data compression is running high, the machine accepts data at a higher rate and the net time for transmission of the total frame is short. If the data compression is low, the image terminal accepts data at a lower rate, and the net transmission time is longer.

The EICS functions by repeating some of the data at the receiver terminal. When the line and sample dropping algorithms are utilized to compress the non-target areas, the lines and samples that are transmitted are repeated at the receiving terminal.

The design of the EICS is such that the output rate is constant, and the transmission time for the photo is the variable. The upper bound of the transmission time is governed by the speed of the drum, while the lower bound of the transmission time is governed by the speed of the link. Thus, there is a interval of transmission times which range from about 2 minutes to 22 minutes depending upon the busyness of the imagery, and the proportion of target to non-target area of the photo selected for compression and transmission.

The drum design of the image terminal and the function of the system allows for a electronic blow-up of the discrete areas of the imagery. Thus, one can scan a 2x2 inch area, electronically zoom up to either 4x4, or 8x8 inches. Within the smaller target areas, Redundant Area Coding can also be applied such that within the smaller scanned area, compression can be applied and at the same time, be blown up to a larger format.

The EICS Is being considered for field use and will be implemented after the demonstration tests are complete.

James J. Maier
JAMES MAIER
Project Engineer

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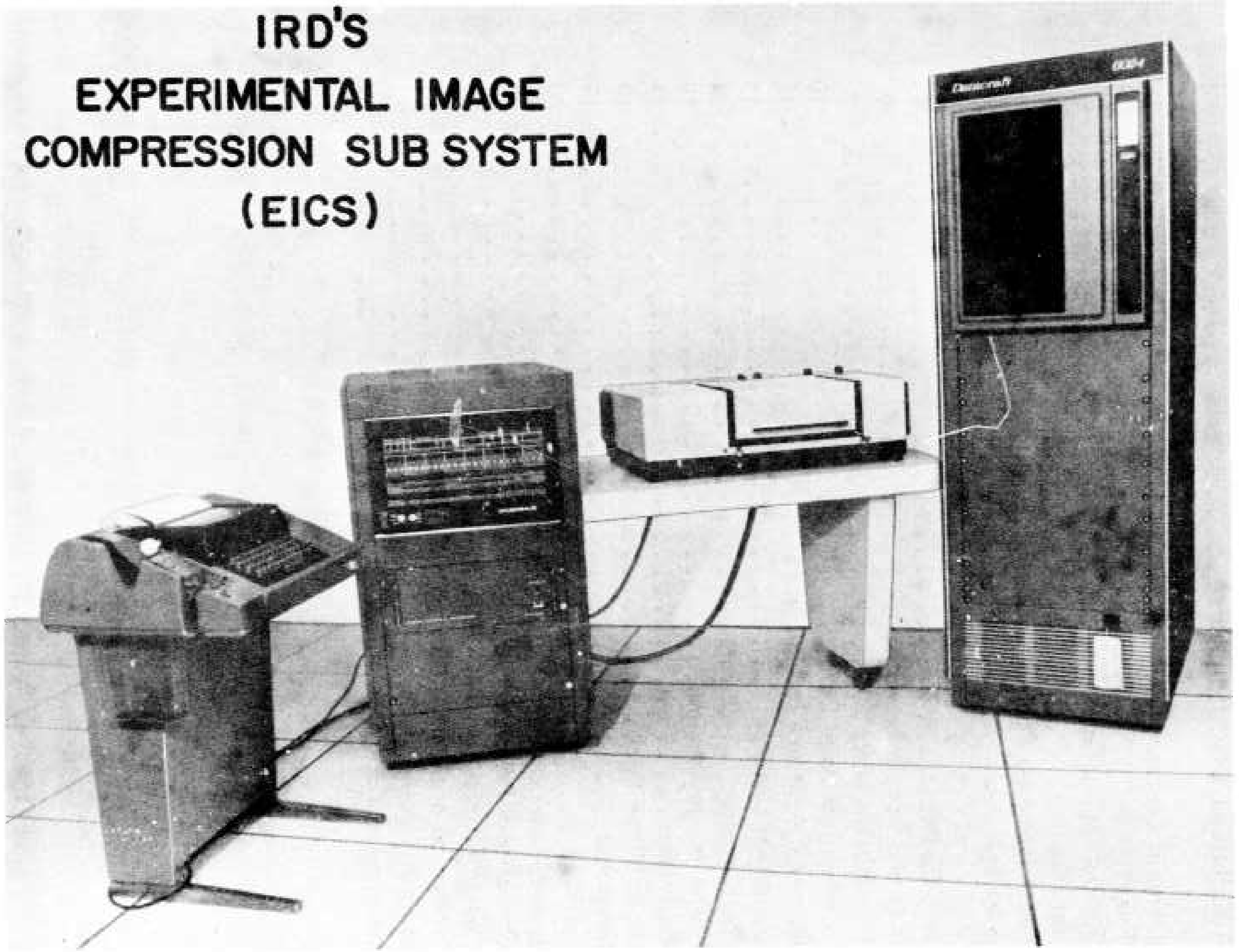

Frontispiece

1.0 INTRODUCTION

The Experimental Image Compression Subsystem (EICS) was developed to effectively transmit intelligence and reconnaissance image data over narrowband links in minimum time. It makes use of the Redundant Area Coding[1,2] (REARCS) technique developed by RADC,[3] to obtain transmission time reductions of 15 to 1 and more. For instance, a 9 x 9 intelligence photo could be transmitted in five minutes over a 9.6-kb/s wire line link. This photo would carry intelligence data with 64 grey levels and 20 lp/mm resolution. The basic techniques for the hardware system design were developed using the results of a software simulation on the RADC sponsored Redundant Area Coding Image Link Simulation[4] Program.

The quality of the image transmitted by the EICS has proved to be highly satisfactory for use in the intelligence and reconnaissance areas. The REARCS technique, used in conjunction with spatial source coding and zoom techniques, has provided highly effective image data with transmission reduction times mentioned above.

The report briefly describes the general concept for the system and the coding techniques employed. It then discusses the transmission links, the synchronization of the data, and the effects of link errors. The equipment is then described followed by operational performance characteristics, picture quality, and transmission times. Sample pictures are included to demonstrate the system performance. Last, recommendations for the future of the EICS Terminals are explored.

[1] William M. Sillers, "Redundant Area Coding Study," RADC-TR-71-192, Rome Air Development Center, Rome, New York, September 1971.

[2] Air Force Invention U.S. Patent No. 3743765 Redundant Area Coding System 4 March 1970.

[3] L. Gardenhire and J. Maier, "Redundant Area Coding System," International Telemetering Conference, 1972.

[4] William M. Sillers, Jr., "Redundant Area Coding Image Link Simulation," RADC-TR-73-185, Rome Air Development Center, Rome, New York, July 1973.

2.0 TECHNICAL DISCUSSION

2.1 General Concepts

2.1.1 The Problem

There were two areas to look at during this program: the systems concept and the hardware implementation. The overall systems concept had to be defined so that the right hardware concepts could be subsequently developed. Prior to this program, a system concept did not exist. The REARCS technique had been developed as an isolated new technology exploration which appeared to have application in the reconnaissance field.

The hardware, which was the purpose of this program, was developed to meet the intent of the system concept. Even though it was determined to be experimental hardware, it should demonstrate applicability to meet future system needs. The equipment should be sufficiently operational to allow field demonstrations for the purposes of evaluating both hardware and image quality for future applications. Further, the hardware concept must implement the complex coding, synchronizing, and produce excellent picture quality at a low cost. The Radiation 6401A Image Terminal was selected as the picture scanning and reproducing hardware system.

2.1.2 System Application

The application of the EICS in the Air Force intelligence and reconnaissance areas, is shown graphically in Figure 2.1.2. The desired system parameters are listed as follows.

Desired Parameters

1. Link	a. Narrowband - wireline, tropo, HF or Microwave, transmit usable picture data with up to 10^{-3} link error rate.

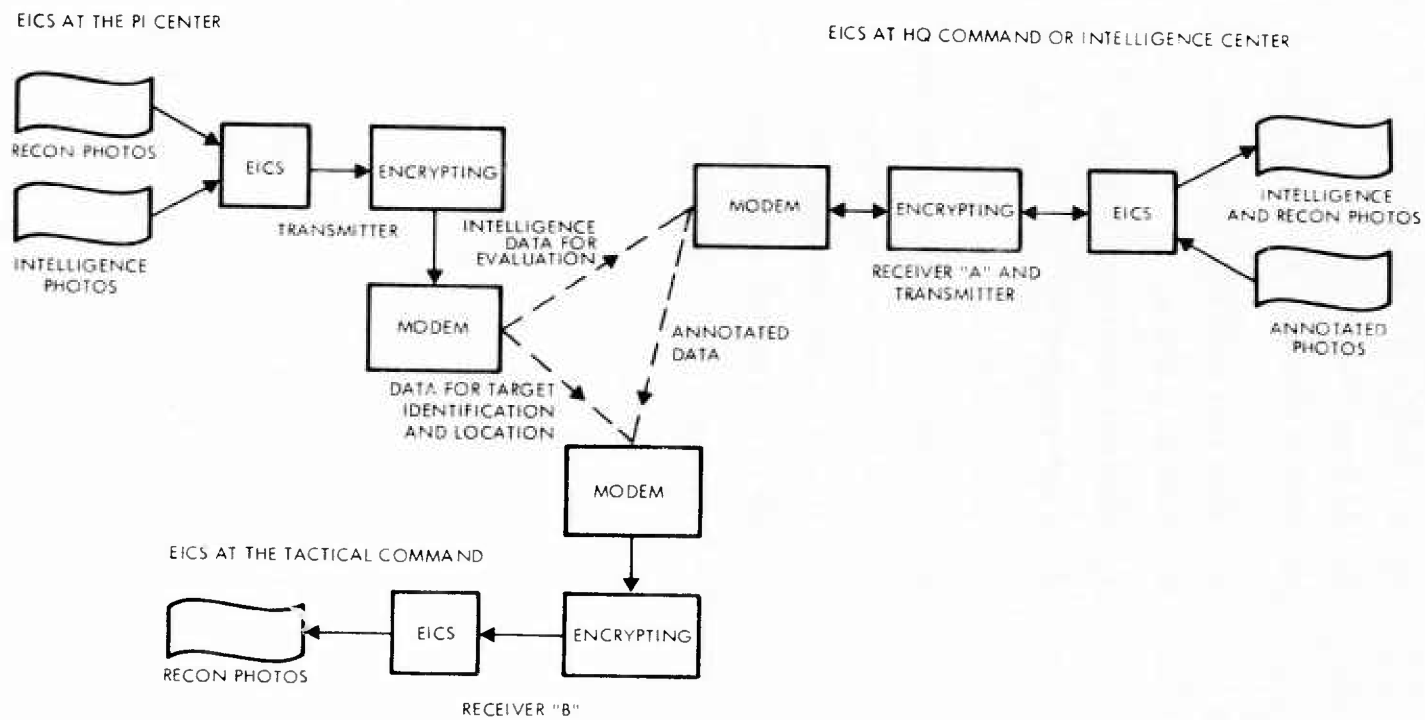

Figure 2.1.2 EICS Application

2. Image Quality	a.	9 x 9 and 5 x 5 format size
	b.	2 - to 40 - lp/m scanning
	c.	64 grey levels
	d.	Picture expansion of up to 8 times
3. Transmitter/Receiver A (See No. 4)	a.	Desk type or floor standing unit
	b.	Manual operation
	c.	Minimum operator intervention
	d.	Duplex operation
4. Receiver A /Transmitter (See No. 3)	a.	Desk type or floor standing unit
	b.	Automatic wet processed film output
	c.	Minimum operator intervention
	d.	48 hours unattended operation
	e.	30-minute downtime to change chemicals
5. Receiver B	a.	Field deployable ruggedized unit
	b.	Dry process paper copy output
	c.	48 hours unattended operation
	d.	5-minute downtime to change paper
	e.	Provision to make multiple copies
	f.	Only 5-lp/m scan resolution and 16 grey levels
6. General	a.	Asynchronous digital operation
	b.	Apply REARC and spatial coding to reduce transmission time for all pictures
	c.	Redundant area coding selected by grid technique

2.2 Data Coding

The EICS employs the following source coding techniques to reduce the amount of data transmitted for each picture.

2.2.1 Redundant Area Coding

The purpose of the Redundant Area Coding Scheme (REARCS) is to reduce data content in a picture so it may be transmitted in minimal time over a narrowband link. Since not all areas of normal reconnaissance pictures carry the same level of interest, only the areas of high information need to be transmitted exactly. The low-information (redundant) areas are used primarily for orientation, so they can be coded for transmission at the maximum data reduction rate and still be effective. Based on these facts, the REARCS approach applies different coding techniques to the two types of areas. In the nonredundant area, a statistical coding is used to preserve all of the data by coding the data exactly as it is digitized. Conversely, in the redundant areas, an interpolative step technique is used that can be combined with lowering the resolution to obtain greater reduction.

2.2.2 Area Selection

The redundant and nonredundant areas of the picture are selected by the computer operator using a grid matrix. The coding techniques in the various boundary areas are also selected by the operator.

A one-inch grid matrix covering the 2048 x 2048 pixel area (8 inches x 8 inches picture at 256 lpi scanning) has been programmed within the system. The operator can select the type of coding to be applied within each square of the grid. Selection is made by row and column designation on a standard teletype. Two hundred fifty-six (squared) pixels comprise a 1-inch grid square of the 2048 x 2048 pixel area.

2.2.3 Statistical Coding

Given the absolute value of one pixel as the starting point, statistical coding encodes the changes in grey level between adjacent pixels. The frequency of occurrence of different delta values follows a definite statistical pattern; no-change and single-level changes occur most frequently, while two- and three-level changes occur less often.

Table 1 gives the statistics of the level changes which were determined by measuring many types of pictures. The statistics show only small percentage differences between busy and quiet pictures.

Table 1. Level Change Frequency

	Huffman Code	Statistical Occurrence (In Percent)
No change	1	6.5
One-level change +	01	12.1
One-level change -	001	12.1
Two-level change +	00011	2.0
Two-level change -	00001	2.0
Three-level change +	0000101	1.2
Three-level change -	000100	1.2
Four-level change +	0000011	0.4
Four-level change -	0000001	0.4
Remainder code	0000010 (followed by a 6-bit data value)	0.6

In order to assign a unique code to each event, a Huffman coding approach is used. The most likely events, naturally, are assigned the shortest codes. All changes of more than four levels are assigned a new reference by assigning a special code with the absolute 6-bit value of the sample sent right after the code. This form of coding yields 2.0 to 2.4:1 data reductions, depending upon the activity of the picture data. The outstanding characteristic of this code is that it is noninterpolative or entropy-preserving. Thus, if no link errors are introduced, the decoded data will be exactly like the input.

2.2.4 Step Coding

The step coding algorithm is a zero order reduction technique, which is an interpolative type technique. The code fixes a reference point with the "next sample" and establishes a tolerance around this point. Then, the subsequent sample is examined to see if it lies within this tolerance. Each new sample is examined to see if it lies within the tolerance. All consecutive values within the tolerance are transmitted as a single sample with the assigned value of the center of the tolerance range. The count of the samples falling within the tolerance is transmitted as a run length. When a sample falls outside the tolerance, a new "next sample" reference is established using this sample. The following samples are then tested against the newly established tolerance.

The tolerance is selected by the operator and ranges from two to seven levels. The run length of samples within the tolerance is restricted to 64.

2.2.5 Line and Sample Repeating

The program is capable of reducing the resolution by dropping lines and samples. For instance, to obtain a times four reduction in resolution, every other line and sample is dropped. The remaining sample is transmitted. The transmitted sample is recorded and repeated once on the receiver end. The line is also repeated on the receiver end, thus filling in the line that was dropped in the transmission.

2.3 Transmission Links

There are several possible transmission links over which tactical imagery data may be transmitted. These include:

- Troposcatter
- LOS microwave
- Wire line
- Satellite

The major characteristic that all of these transmission links have in common is that they are voice grade circuits and, hence, have analog bandwidths of approximately 3.5 kHz. The rate at which digital information can be transmitted over these links depends upon the frequency response of the channel, stability, noise characteristics, modem available, and tolerable bit error rate. Extensive tests have been performed by RADC of error rates for 9.6- and 4.8-kb/s modems over tropo, satellite, and cable links. These tests show that many satellite and cable links will support 9.6-kb/s transmission with acceptable error rates (10^{-4} to 10^{-5}) while most tropo links have more than 1 in 10^4 errors even at 4.8-kb/s transmission rates.

We feel it was reasonable to design the EICS to operate over 10^{-3} links and provide usable copy.

Since some of the candidate transmission links will support 9.6 kb/s, as will Bell System C-4 lines which may be useful for testing, the demonstration equipment is capable of handling this maximum rate. Since lower rates will probably be required for tropo systems, the demonstration system is able to selectively operate at transmission rates of 9.6, 4.8, 2.4, and 1.2 kb/s. These are all common modem rates and will provide a flexible test mechanism.

2.4 Synchronization of Data

A complex synchronizing approach has been employed to minimize the effect of link errors upon the received data. The fact that source encoding has been employed makes a single bit error affect the remainder of the coded data in the line. To minimize this effect, all codes are re-initialized every inch of the picture (i.e., every 256 input data samples).

There is a 30-bit Barker Code and its complement employed to synchronize each new line of transmitted data. These are employed as follows:

Codes

3	Complement codes	Start of picture
1	Code	Start of line with step-coded or statistical-coded data only
2	Codes	Start of line with step and statistical codes combined
2	Complement codes	Start a new vertical grid
3	Complement codes	End of picture

In addition to this, there is a code after each 256 samples (1 frame) of data. The reconstructed samples are counted when the data is received and decoded. If a link error was present between codes or a code detected improperly, the error is detected by a miscount.

2.5 Cosmetic Approach to Link Errors

If an errored frame of data was printed on the received copy, the copy would contain information not in the original picture. This could be confusing to the viewer. Taking advantage of the high coordination between adjacent lines of data, the previous (adjacent) good line can be substituted for the errored line and still provide valid data in the completed picture.

This system repeats the previous line for the frames (256 pixels) where errors have been made.

2.6 Equipment Concept

The EICS is illustrated in the simplified block diagram of Figure 2.6-1. The component layouts of the system are shown in Figure 2.6-2 with individual components discussed in detail later in this section. The system consists of transmit and receive terminals, which interface with a narrowband link facility or operate back-to-back. The

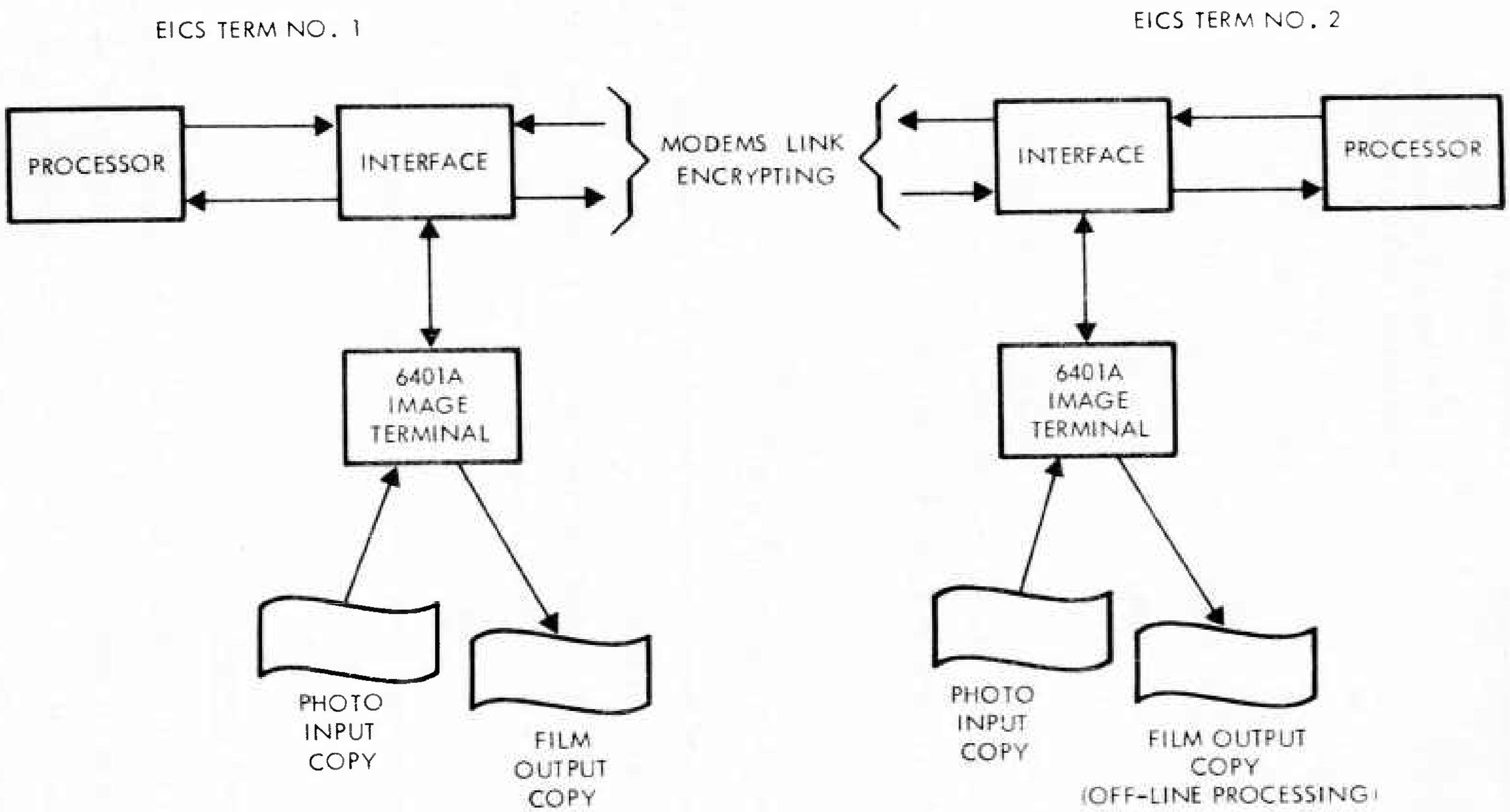

Figure 2.6-1 EICS Block Diagram

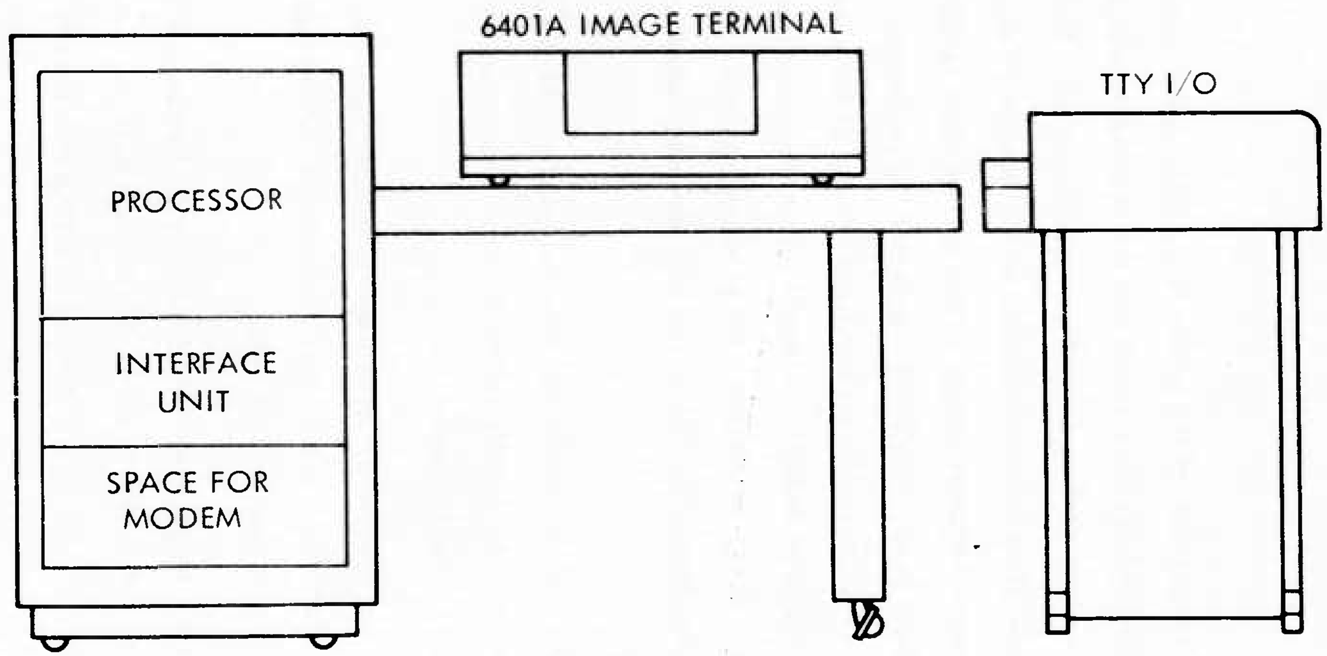

Figure 2.6-2. Component Layouts

system then can operate as experimental laboratory equipment or demonstrate REARCS techniques over real image link.

2.6.1 The Processor

One of the basic components of the system is a miniprocessor used to perform the coding and buffering functions in both the transmit and the receive terminals. Use of a miniprocessor was chosen in place of a hard wired block box concept. The complexity of the REARCS scheme would have placed a severe burden on the equipment design engineer to implement the prototype hardware design within a reasonable budget. This factor always places the equipment in an undesirable cost/schedule/performance trade-off position. The processor scheme requires a software approach which, at the present time, is very much under control as a result of Radiation's recent software performance on the Image Link Simulation program.[5] Then, in addition, the processor approach provides a system which can adapt to new requirements. The system will not reach obsolescence the day the first tests are completed.

The Datacraft 6024/5 miniprocessor has been selected for the processor in this subsystem because its capabilities are ideally suited for this system's requirements. These capabilities are summarized in the following list:

a. The machine has a 600-instruction repertoire which provides for bit manipulation which is a primary requirement for the type coding/decoding being implemented.

b. The 24-bit word length allows the 6-bit data to be packed four input words to the computer word. This allows optimum use of buffer storage. All locations in the 4K memory are directly addressable.

c. Priority interrupts needed to service the real-time terminal and data link inputs are standard features of the machine.

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[5] Sillers, Jr., Op. cit.

d. The machine can be easily expanded for future applications by adding more directly addressable memory and peripherals.

e. It has a 1-μs cycle time.

The processor will implement different redundance removal encoding algorithms in two select areas of the image, making it ideal for REARCS type processing which utilizes separate redundant and nonredundant areas. The particular area being processed at any instant is automatically determined by the processor input parameter. Within each of the two separate areas (AREA A/AREA B) the following processing algorithms can be independently selected:

- Statistical coding (6 bits) Area A
- Extended step coding

  2- to 7-Bit tolerance
- Line and sample repeating Area B

  1 Line/sample

  3 Lines/sample

The processor also formats the encoded data such that automatic decoding and reproduction is possible at the Receiving Station. The formatting consists of inserting Group (G) Sync and Super Group (SG) Sync at the appropriate intervals. An SG code is sent at the start of each line and a G code is sent at the end of each data block. The variable word length data blocks are each composed of the encoded pixels and the G code word provides a position check and parity count for each individual data block.

2.6.2 6401A Image Terminal

The other principal system element is the 6401 Image Terminal[6] used to scan and record image data on each end of the link. The versatile and wide capabilities of this terminal enhances the system's ability to meet future requirements while meeting its present ones with ease. Feedback controls, coherent optics, precision spot location,

and advanced electronic designs provide the terminal's capabilities. The input image data is scanned on the 6401 Terminal and is presented to the processor as 6-bit quantitized data. The processor accepts the data a line at a time. The processor performs the coding function, adds the synchronizing words, and provides buffered storage.

The 6401A Image Terminal has both a scanning and reproducing capability. Similar terminals are being supplied to RADC on the HRMR and REARCS programs. This terminal is characterized by high resolution and faithful grey level representation. It utilizes a coherent light source to obtain superior performance. The terminal has the following characteristics:

• Resolution	64,128,256,512,1024 lpi
• Copy size	8-1/2 x 11
• Scan size	8 x 10
• Illumination	Laser, 638 A
• Input/output Data	6 Bits
• Input copy	Photocopy, Translucent Film, or Diazo
• Output copy	Film* Off-Line Paper Processing
• Operation	Asynchronous Line Stepping
• Special features	Amplifier Calibrated Each Line
• Linearity	10% Cyclic Error 30% Random Error
• Grey Levels	64 Linearized Levels

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[6] Radiation, Tech Brief, 1-SS-2049

*Kodak 2479 Film and 42570A Paper.

		±1/2 LSB Error
		.01 to 2D Range (Scanning)
		.2 to 2D Range (Reproducing)
•	Timing accuracy	±5% Sample-to-Sample
•	Response	30% at .70 Cy/Spot Diameter

The terminal shown in Figure 2.6-2 is identical to the terminal supplied on the REARCS program. The drum is accessible through a door in the top cover to load and unload copy or film. The control panel is on top of the unit. A light tight changing bag attaches to the front opening to allow loading of film in normal room light.

A block diagram of the Image Terminal is shown in Figure 2.6.2. The basic features of the system are illustrated in the block diagram:

- DC servo drum speed control
- Laser illumination
- Radial position around drum tied directly to calibrated timing marks on drum.
- Linear companding
- Asynchronous operation with stepping motor drive on lead screw
- Feedback gain and offset calibration with each revolution of drum

2.6.3 Parameters

The parameters which determine the type coding, etc., are loaded into the processor prior to starting the transmission. The initial program is loaded into the processor via the paper tape reader. On the teletypewriter, this need only be done once. All coding and grid selection parameters are entered through the teletypewriter keyboard. The status of the program and parameters are also printed out on the teletypewriter as well as the data reduction factor.

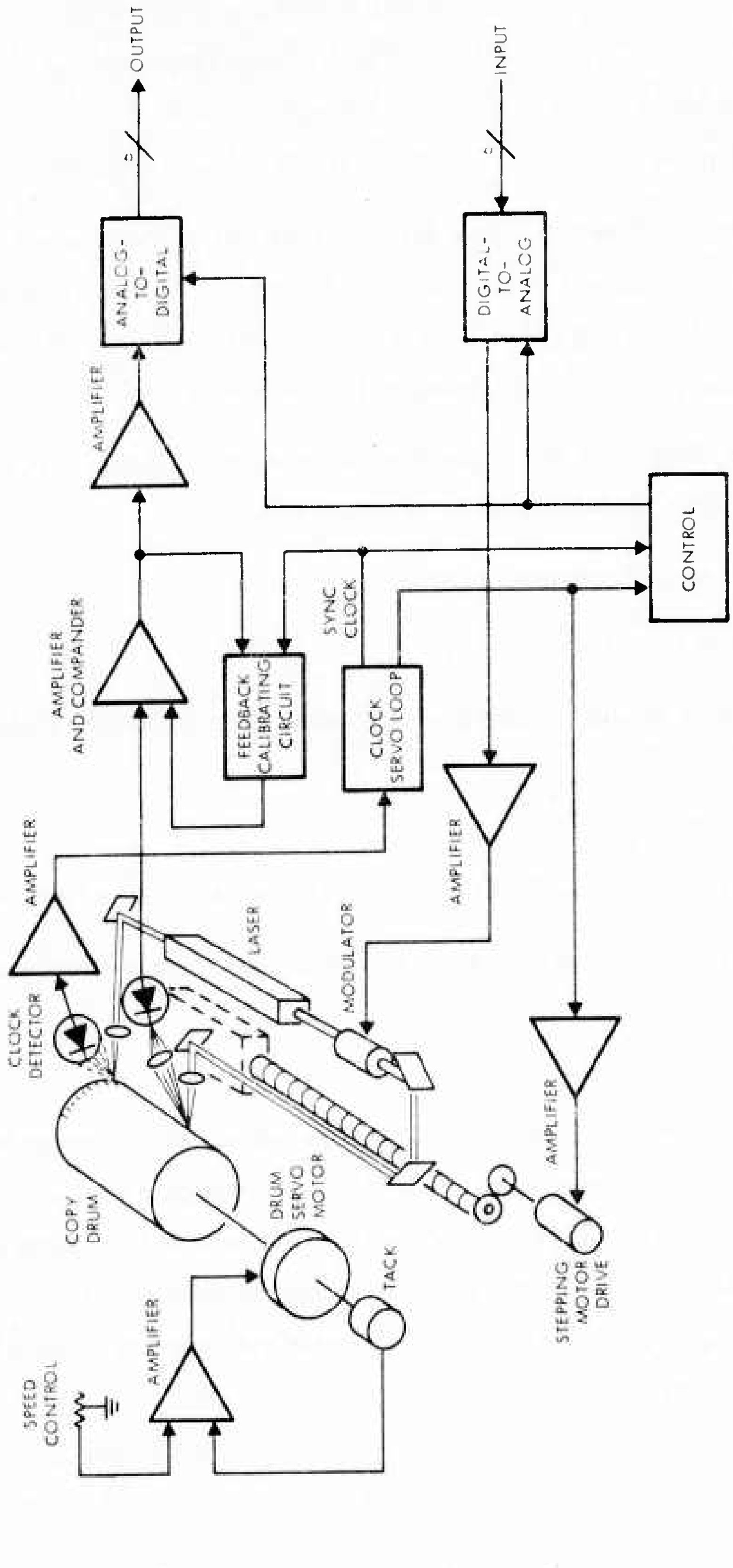


Figure 2.6.2. 6401A Image Terminal Block Diagram

2.6.4 Digital Tape Deck

A digital tape deck is an added feature of the Receiver Terminal. The tape deck can be utilized in several ways:

a. It will record transmitted and reformatted picture data in dicomed format (2048x2048 pixels).

b. It will record scanned data directly from the 6401A Terminal for use in the Image Simulation programs on the GE 635 Computer.

c. It will play back picture data to be recorded on the 6401A Terminal.

The standard data format on the tape will be 2048 6-bit words per record; 1 record per line. There will be a maximum of 2048 lines per picture.

A magnetic tape deck and Tape Controller Unit (TCU) are supplied with the receiver unit only. The tape deck is a model unit with the following specifics:

a. 9-track IBM format

b. 75 ips

c. 800 bpi

d. 10-1/2-inch reel

The TCU matches the tape unit to the processor.

2.6.5 Interface

This hardware box interfaces the 24-bit computer I/O bus with the serial bit stream to and from the modem. The modem timing is used to format and transfer data to and from the computer. The interface also handles the 6-bit data samples to and from the 6401A Image Terminal. It also provides the control signals to the terminal.

A hardware correlator to detect the 30-bit Barker coded sync word is located in the interface. This was done to ease the computation burden on the software.

The processor will operate with a wide variety of modems/transmission lines with rates of 1.2, 2.4, 4.8, and 9.6 kb/s. The processor can also be used in other special configurations as described in later portion of this section. In addition to interfacing with a modem, the Transmit Processor can be connected directly to the processor in the Receiving Station to allow back-to-back operation of the system. This is particularly useful for evaluating the performance of the various encoding schemes in an error-free environment.

The Receiving Station is identical to the Transmitter. When loaded with the receiver program, it performs the inverse operations of the Transmitting Station on the encoded data, reproducing 6-bits per pixel data and buffering it out to the display terminal.

2.6.6 Software

The Datacraft 6024/5 has been selected for the Experimental Image Compression Subsystem. The 6024/5 has a 24-bit word length which has been demonstrated to have many advantages over the shorter word length machines. Chief among these is the extended addressing capability of the 24-bit word. In most smaller word length machines, a memory reference instruction requires two words of storage to contain the instruction which necessitates two memory cycles to fetch the instructions. This is a penalty in both time and memory which the 6024/5 need not pay. Each 24-bit instruction word has the capability of directing addressing 32K of core storage. Immediate instructions (i.e., an instruction which contains all the information necessary to carry out that instruction) are another benefit of the 24-bit word. These instructions, in effect, increase the processing speed since the CPU does not have to make a second access to obtain the operand. For the EICS application, the 24-bit word offers a special advantage in that four data samples may be packed in one word (6-bits per sample). This makes only 1K of core storage necessary to store 4096 input data samples and makes only one memory access necessary to store or retrieve four data samples.

2.7 System Performance

The overall performance of the experimental equipment is very good. The picture of the received photos is excellent, even under the constraint of manual processing of the film.

The data reduction of 10 and 12 to 1, which were postulated as a result of previous study work, was achieved in the EICS.

2.7.1 Operational Performance

The operation of the system has proved to be easy to manage even though it is an experimental system. The operation is smooth enough so that the manual aspects of the operation will not affect the evaluation of the system approach during field testing. Care is required in setting the controls on the equipment and entering data into the computer. The manual for the system covers these in a step-by-step manner.

Loading the film on the 6401A Image Terminal has proved to be quite easily done with the daylight loading changing bag on the machine. The film is placed back in a light-tight box for off-line processing.

The recommendations section of this report covers equipment improvements which will simplify the operation of the system. These apply primarily to reducing the complexity of the operator controls and making film handling and processing automatic.

2.7.2 Coding Efficiency/Transmission Times

The effectiveness of coding to reduce transmission time depends upon the combination of coding techniques used and the amount of nonredundant area. The curves of Figure 2.7.2 provide an example of the reductions obtained for various coding combinations. The data is shown for a picture with average activity and will vary for different pictures.

The equipment places a restriction on the minimum possible transmission time and this is shown on the curve of Figure 2.7.2. The picture can only be scanned as fast as the drum will turn on the 6401A Image Terminal. If the coding information reduces

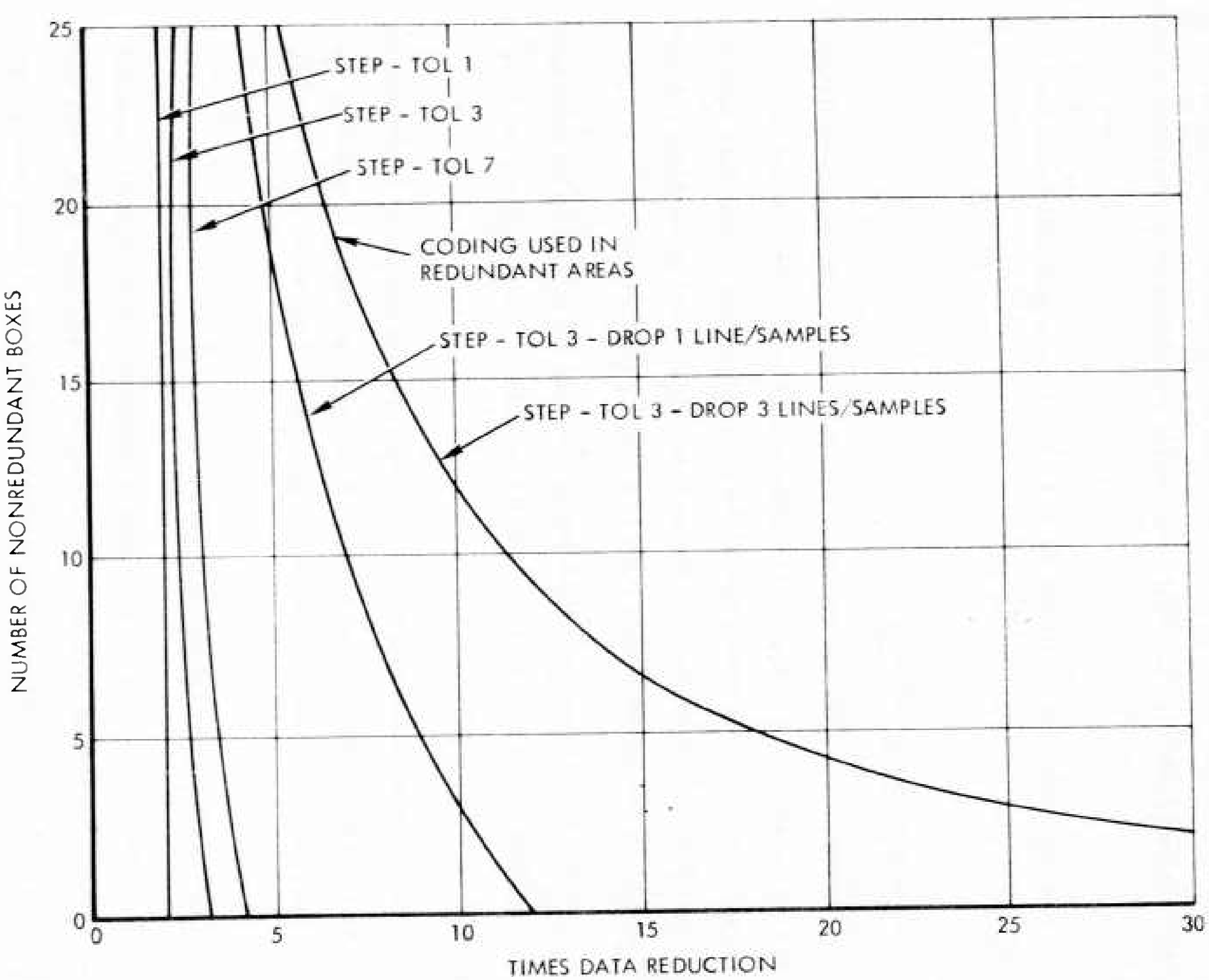


Figure 2.7.2. Curve

the data to a point which is below this minimum time, the system will just leave blank spaces in 9.6-kb/s fixed rate output data stream. In future systems, the speed of the drum can be increased greatly to overcome this problem.

2.7.3 Evaluation of the REARCS Picture Format

We are confident that the use of redundant area coding will produce pictures usable in an operational environment from the tests that have been run thus far in a controlled environment. This is because in most intelligence and reconnaissance photographs only a small area of the picture requires that high resolution need be maintained. The remaining area is only for purposes of orienting the detailed area. Under these conditions reduction of 12 to 15 : 1 are possible. (See Figure 2.7.2.) The 8 inch X 8 inch grid matrix (1 inch X 1 inch at 256 lpi) seems adaquate to designate the areas of high interest.

2.7.4 Sample Pictures

The pictures in this section are representative of the system performance. Each picture is accompanied by a description of the important system performance parameters demonstrated by the picture. All pictures were originally recorded on Kodak 2476 film and developed in D-76.

2.8 Recommendations

The use of the REARC technique in the EICS terminal has proved effective in reducing the transmission time of reconnaissance and intelligence photos. Test modes thus far indicate that the transmitted picture quality is acceptable to meet the mission requirement. What is recommended at this point is to operate the EICS in an actual tactical reconnaissance and intelligence environment. Operating in the user area will test the concept and provide valuable feedback on future system improvements.

There are several improvements to the Experimental Terminals which are obvious at this point. These improvements are divided into hardware and software categories as follows:

Hardware Improvements

a. The 6401A Image Terminal should be automated to provide for unattended operation at the receiver end. This requires a 3- or 4-day supply of film at that station. Automatic is also required - either wet processing or dry film processing (when the dry media is acceptable for military use).

b. Add the capability to expose dry process media to the 6401A Image Terminal. This requires a more efficient modulator and a larger laser to obtain more light output.

c. Add an alphanumeric CRT display to act as an editing device for the PI's description of the photo and target data prior to transmission.

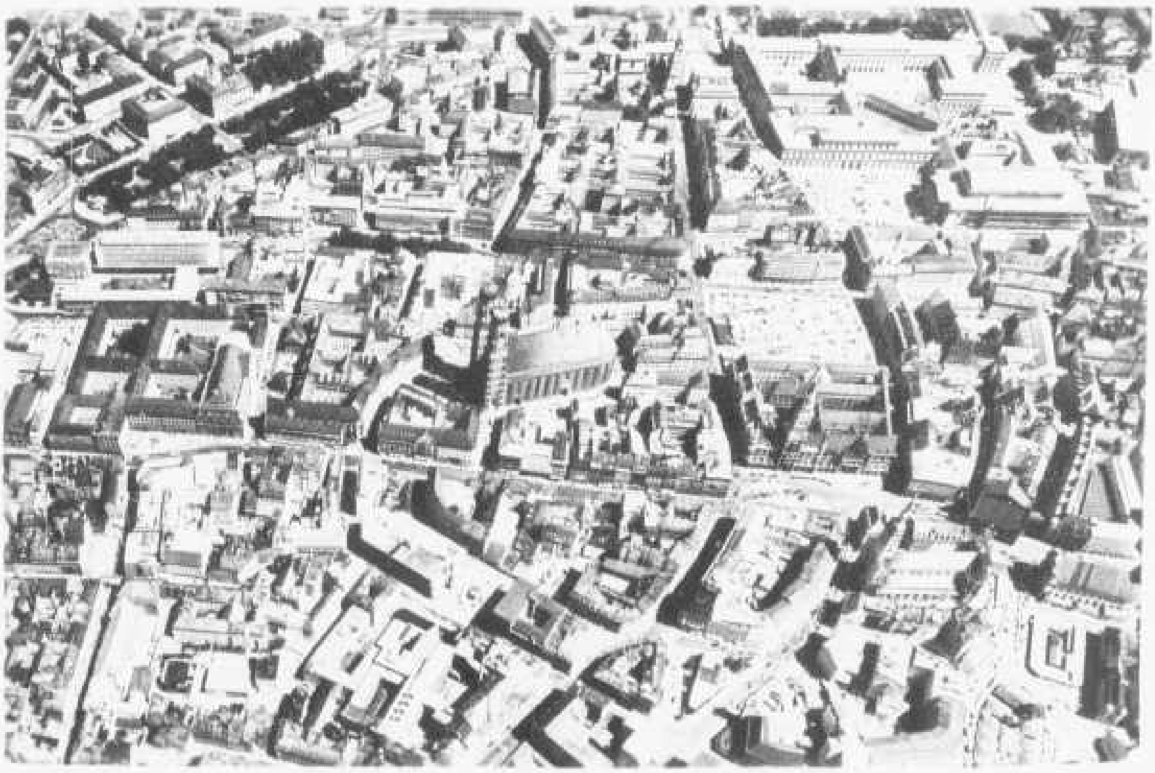
Software Improvements

a. Transmit a software generated message header which will contain all the information required to automatically set up the receiver terminal to process the picture (i.e., resolution, grid locations, code type used, etc).

b. Automatically transmit the PI's textual description of the photo of targets to be printed out on the teletypewriter.

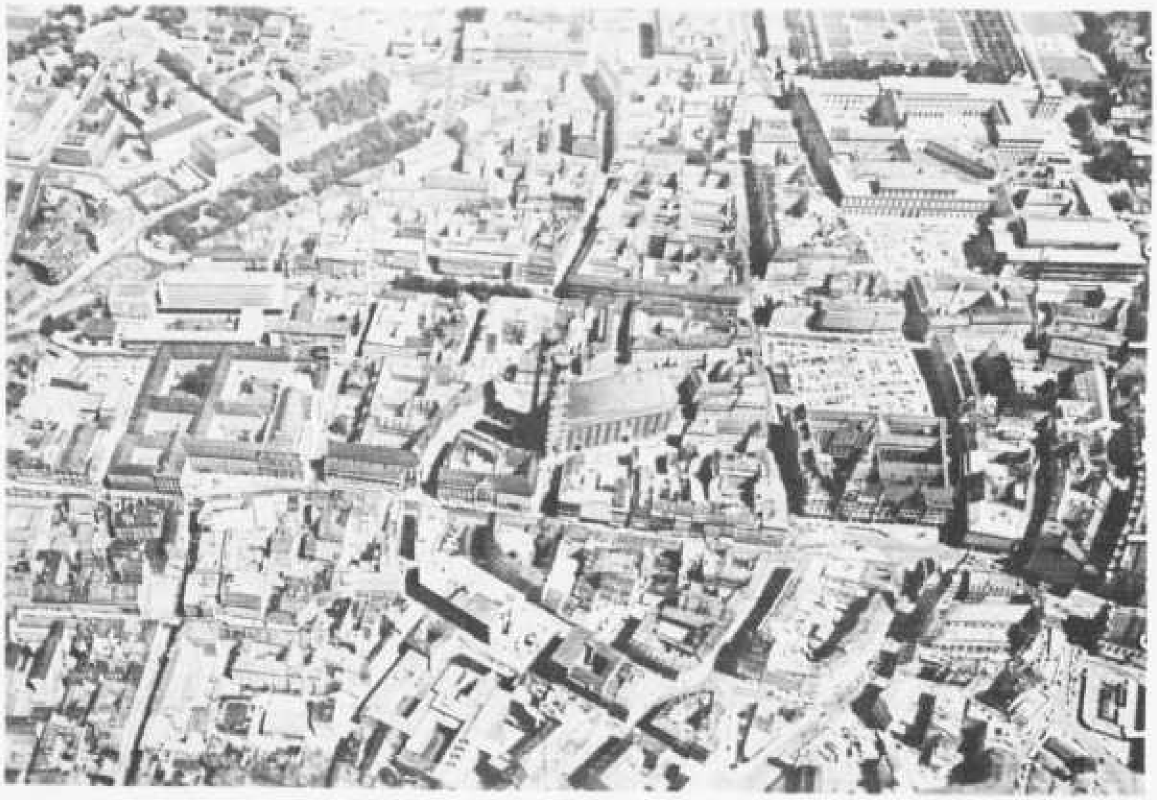
c. Provide a hand-shaking operation between the transmitter and receiver so that the transmitter will know the status of the receiver. It will only transmit when the receiver is ready.

d. Add the capability to code the redundant area using the two-dimensional edge detection technique. This will give a greater data reduction in the redundant areas while maintaining maximum resolution. The present technique of dropping lines and samples lowers the resolution to obtain the data reduction.



Picture No. 1

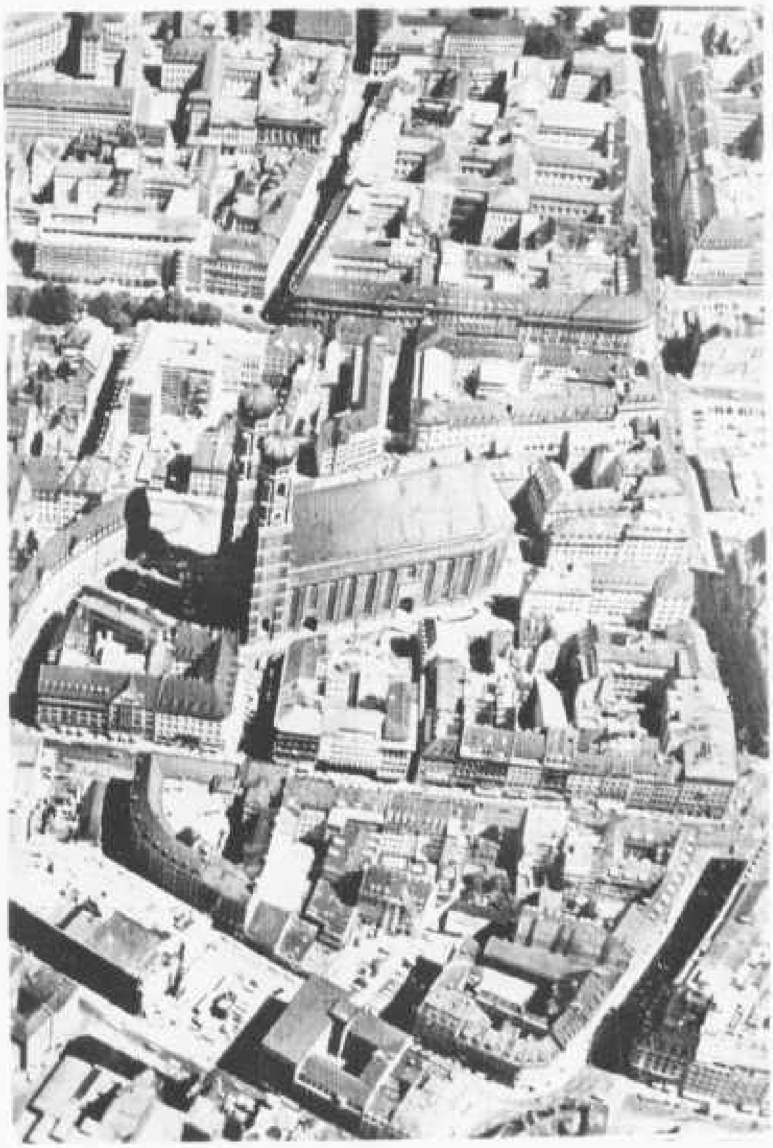
This is a second-generation print of the original Diazo photo copy; which was scanned at various resolutions to obtain Pictures 2 through 7.



Picture No. 2

This is a second-generation print of a positive transparency.

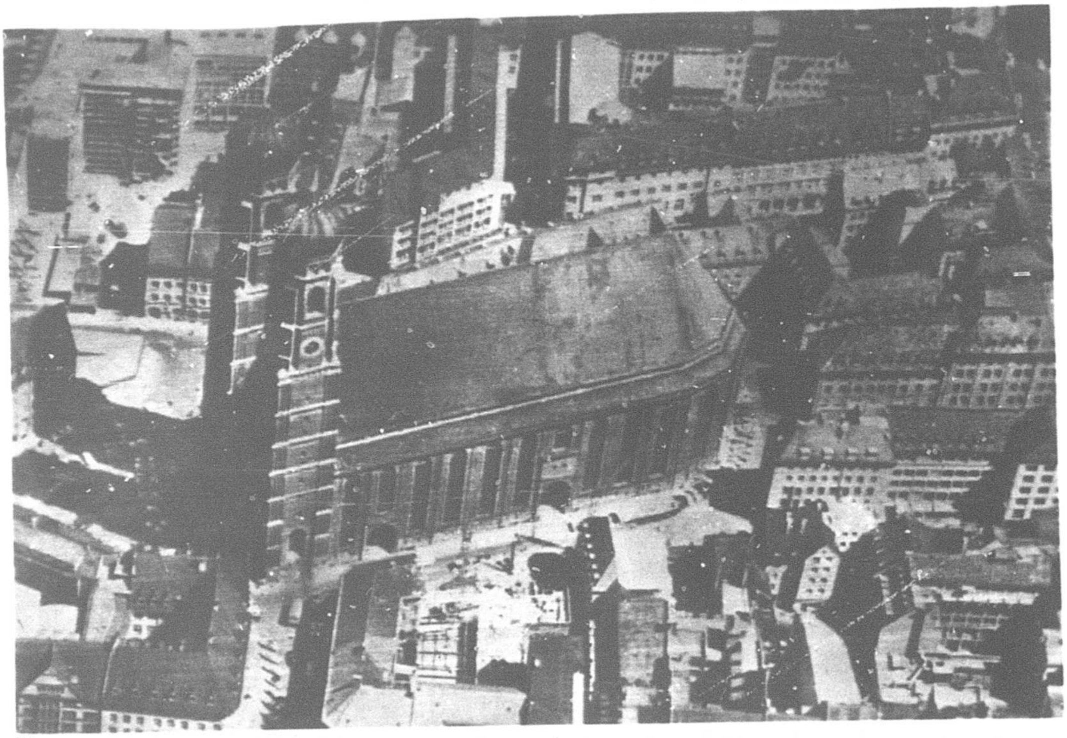
The original was scanned at 256 lpi and 6-bit quantizing, then stored on magnetic tape. It was then displayed on the 6401A Image Terminal from tape.



Picture No. 3

This is a second-generation print of the original film positive transparency.

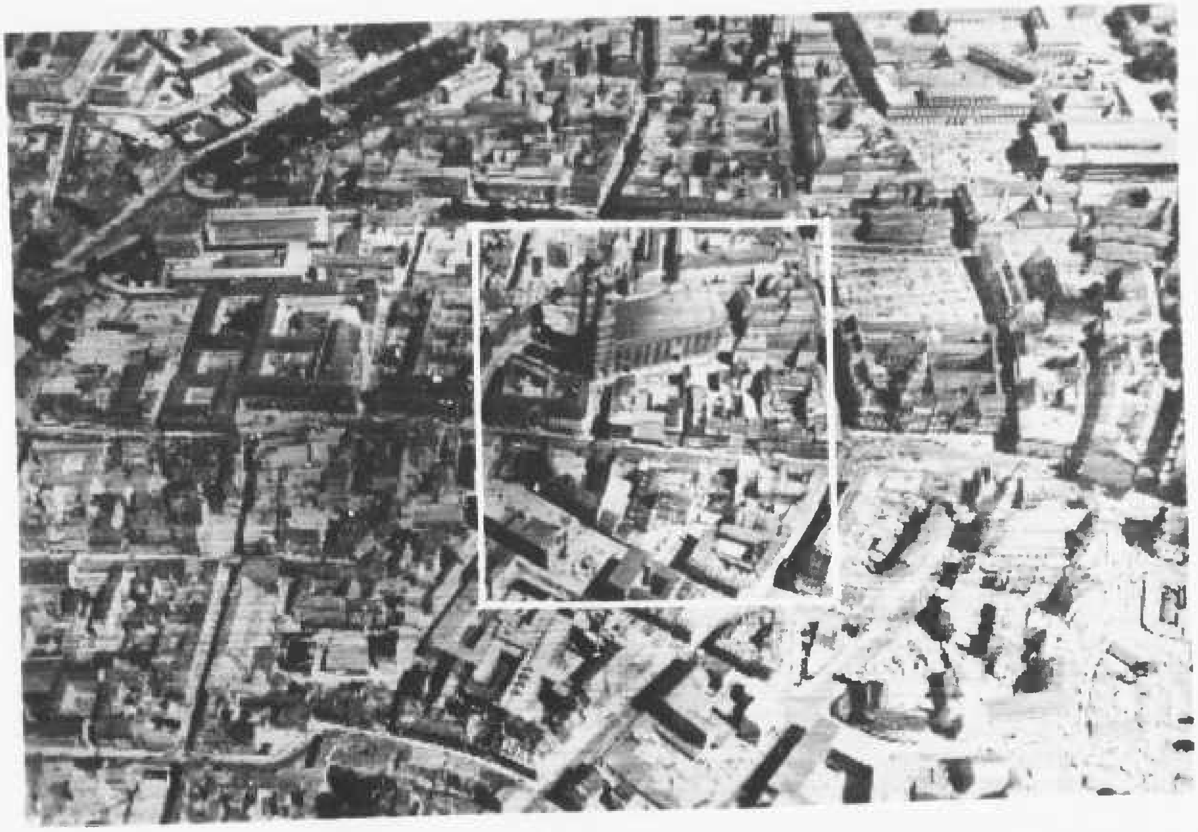
A 4-inch x 4-inch area of the original was scanned at 512 lpi at 6 bits per pixel and stored on magnetic tape. It was then played back on the 6401A Image Terminal at 256 lpi for a X2 expansion.



Picture No. 4

This is a second-generation print of an original film positive transparency.

A 2-inch X 2-inch area of the original picture was scanned at 1024 lpi at 6 bits per pixel and stored on magnetic tape. It was then played back at 256 lpi on the 6401A Image Terminal for a X4 expansion.



Picture No. 5. (Transmitted over the EICS)

This is a second-generation print of the original film positive tranparency.

The original was scanned at 256 lpi, then the following REARC coding was applied.

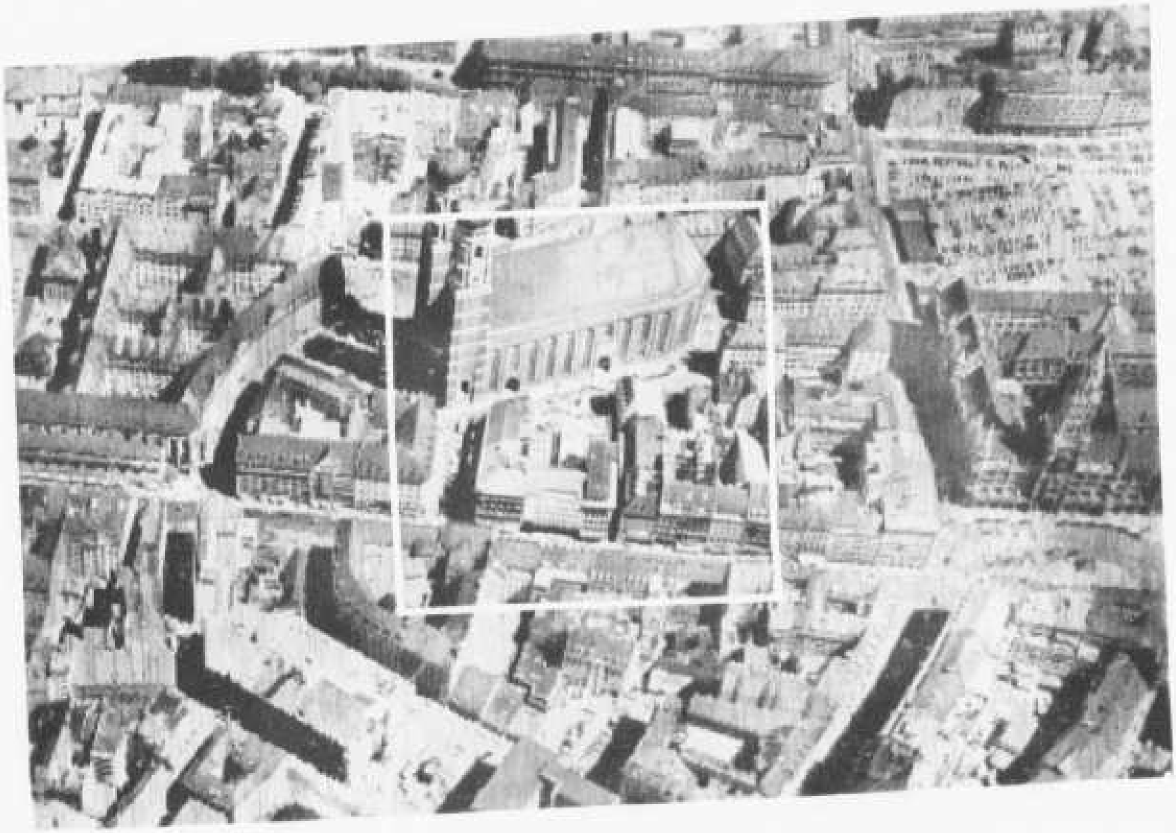
Nonredundant area - (2-inch X 2-inch) 6-bit statistical code.

Redundant area - Step coding with tolerance of three and three lines and samples were dropped.

Reduction - 12.2 times

Transmission time - (At 9.6 kb/s) 5.9 minutes.

The nonredundant area in the 2-inch X 2-inch square is 256 lpi; while the remaining area is about 64 lpi.



Picture No. 6. (Transmitted over the EICS)

This is a second-generation print of the original film positive transparency.

A 4-inch X 4-inch area of the original picture was scanned at 512 lpi. REARCS coding was applied to the data:

Nonredundant area - (1-inch X 1-inch of the original picture) 6-bit statistical coding applied.

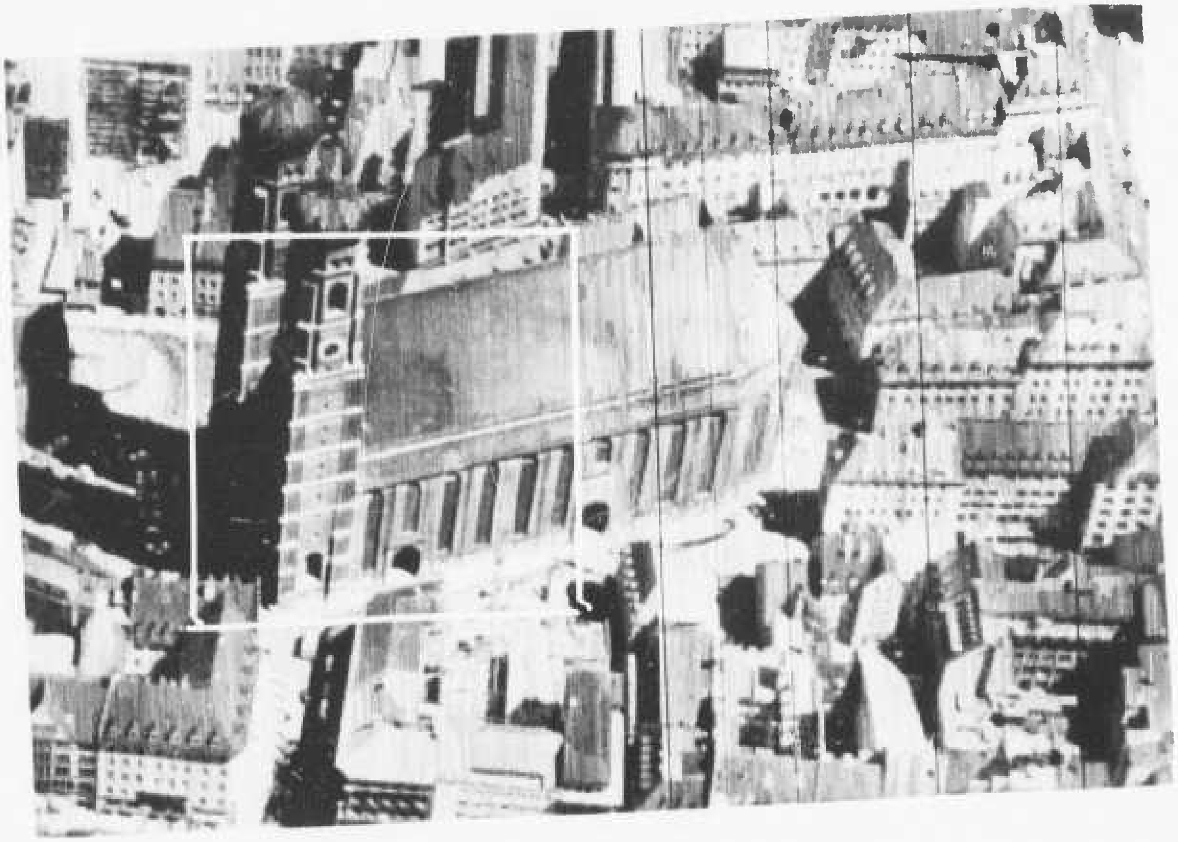
Redundant area - Step coding with a tolerance of three and three lines and samples dropped.

Reduction - 12.4 times

Transmission time -(At 9.6 kb/s) 5.95 minutes.

The picture was reproduced at 256 lpi after transmission.

This results in a X2 expansion of the data, i.e., the 1-inch, nonredundant area becomes 2 inches square with a data resolution of 512 lpi. The redundant area has an effective data resolution of 125 lpi.



Picture No. 7. (Transmitted over the EICS)

This is a second-generation print of a film positive transparency.

A 2-inch X 2-inch area of the original picture was scanned at 1024 lpi and REARCS was applied.

Nonredundant area - (A 1/2-inch X 1/2-inch area of the original) 6-bit statistical coding.

Redundant area - Step coding with a tolerance of three and three lines and samples dropped.

Reduction - 11.9 times

Transmission time - (At 9.6 kb/s 6.1 minutes).

The picture was reproduced after transmission at 256 lpi, which results in a X4 expansion.

The nonredundant area of the picture (the original 1/2 inch X 1/2 inch) was expanded to a 2-inch X 2-inch area by a factor of four. The effective data resolution in this area is 1024 lpi. The redundant area has an effective data resolution of 256 lpi.

Picture 8 (Transmitted over the EICS)

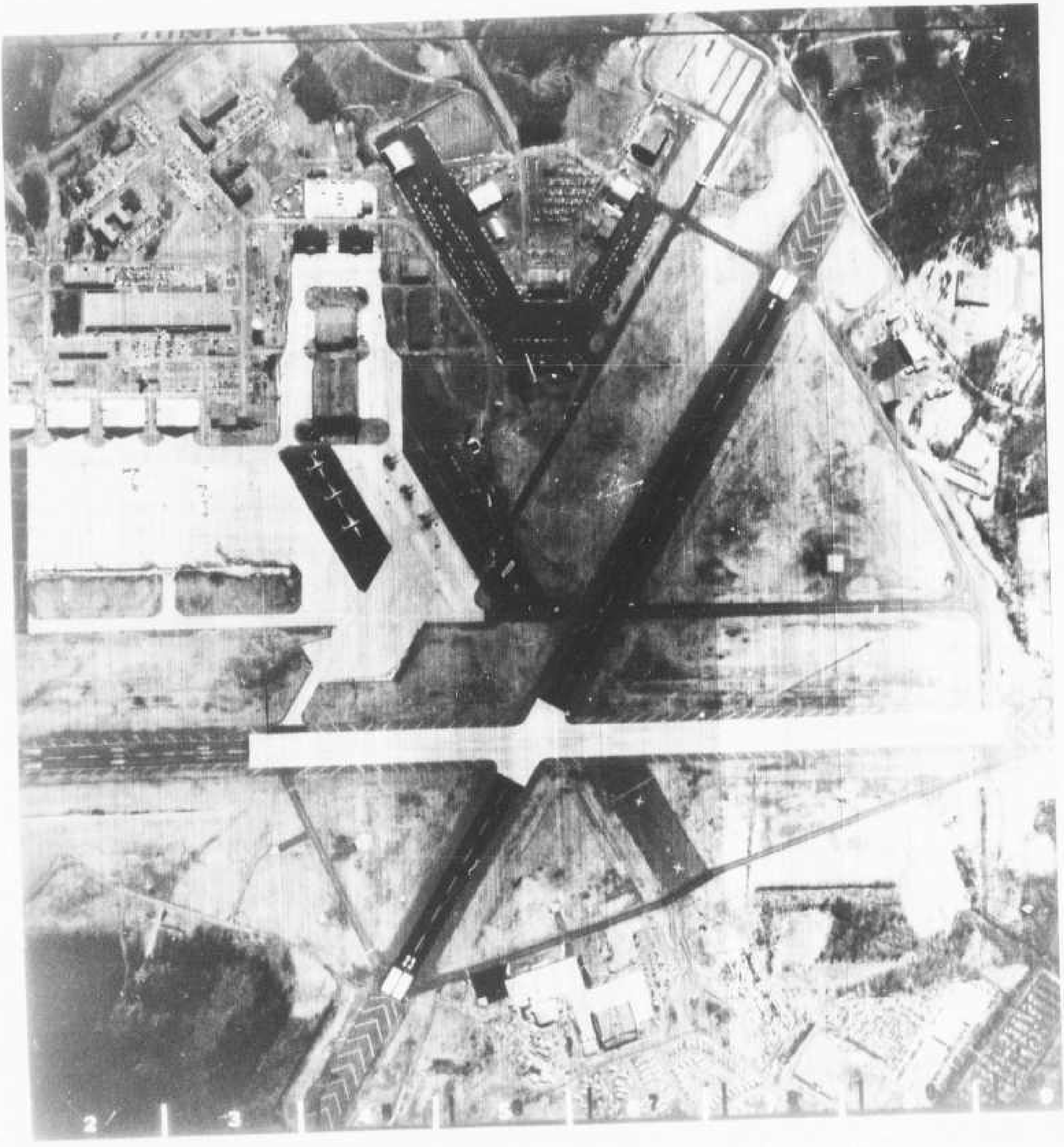
This picture is a second-generation print of the original film.

The picture was scanned at 256 lpi at 6 bits.

Nonredundant area - 6 bit statistical coding applied throughout.

Redundant area - None

Transmission time - (At 9.6 kb/s) 24.20 minutes.



Picture No. 8

Picture 9 (Transmitted over the EICS)

This picture is a second-generation print of the original film positive transparency.

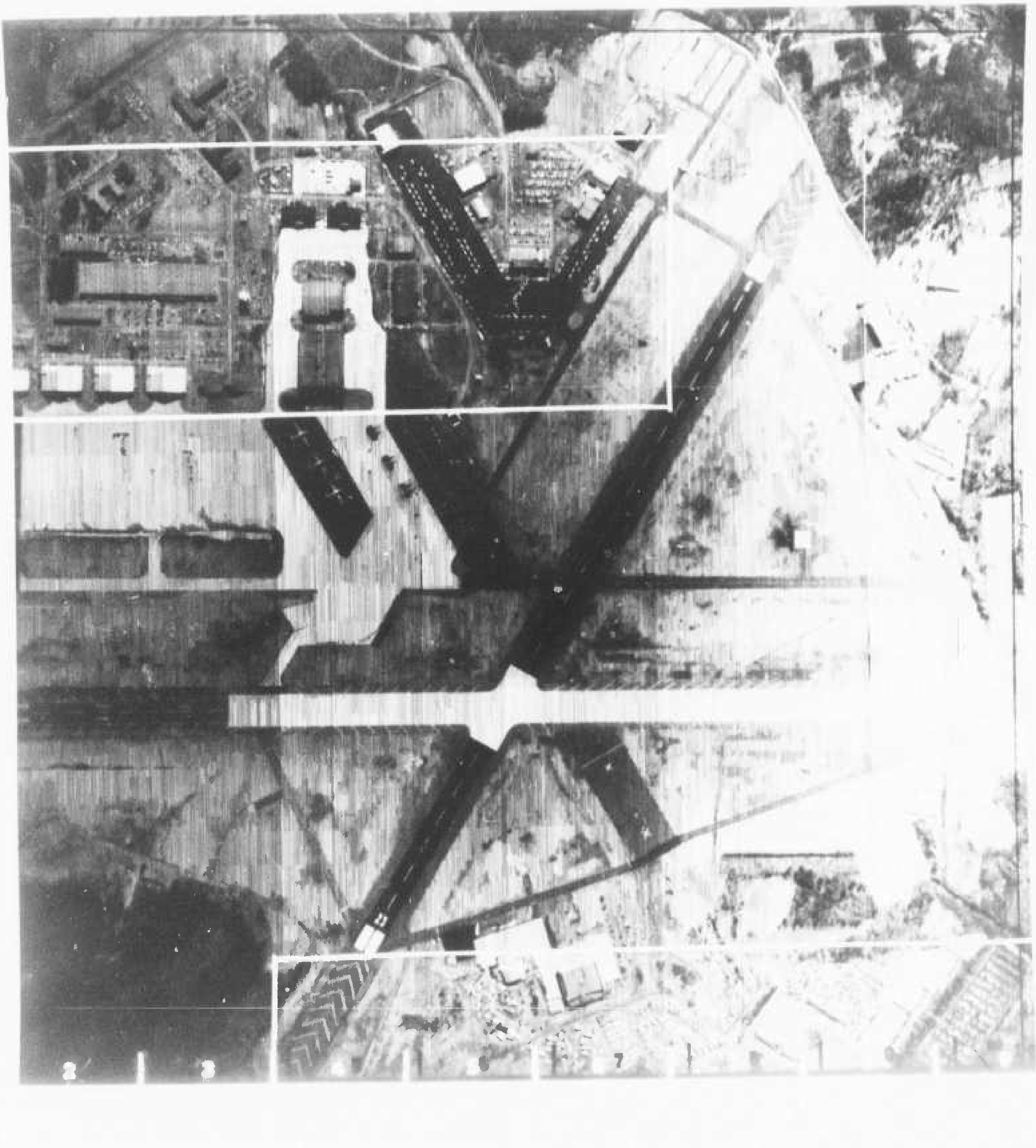
This picture was scanned at 256 lpi at 6 bits per picture element and REARCS applied to the data:

Nonredundant area - (2 areas were chosen totaling 16 boxes)
6-bit statistical coding applied.

Redundant area - Step coding with a tolerance of two and a sample-line drop of one was applied.

Transmission time - (At 9.6 kb/s) 7.85 minutes

The resolution in the nonredundant area of the picture is 256 lpi.



Picture No. 9

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SUPPLEMENTARY

INFORMATION

AD-B002 638L

ERRATA

March 1975

RADC-TR-74-191 dated January 1975
Title: Experimental Image Compression Subsystem (EICS)

The attached paragraph should be pasted over the first paragraph on page 3 of subject report, "Experimental Image Compression Subsystem (EICS)," Contract F30602-73-C-0196, with Radiation, Inc.

1.0 INTRODUCTION

The Experimental Image Compression Subsystem was developed to effectively transmit intelligence and reconnaissance image data over narrowband links in minimum time. It makes use of the Redundant Area Coding[1,2] (REARC) technique developed by RADC,[3] to obtain transmission time reductions of 15 to 1 and more. For instance, an 8x8 intelligence photo could be transmitted in five minutes over a 9.6 kb/s wire line link, with 64 grey levels and 5 lp/mm resolution. Operating in a different mode, a transmitted image would carry intelligence data with 64 grey levels and 20 lp/mm resolution. The basic techniques for the hardware system design were developed using the results of a software simulation on the RADC sponsored Redundant Area Coding Image Link Simulation Program.[4]